Acoustic Communications with AUVs and Autonomous Oceanographic Sampling Network Development

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1 LONG-TERM GOALS

.The general objective is to investigate basic and applied problems associated with the efficacious reconnaissance of littoral waters in support of mine warfare and oceanographic tasks. The particular research topics are basic and applied problems associated with acoustic communications, monitoring, command, and control of AUVs in support of the AOSN concept. Specifically with this proposal, we wish to address acoustic communications between a submarine and an AUV and the implications of networking elements such as AUVs, moorings, and support vessels for oceanographic and mine reconnaissance tasks.

2 OBJECTIVES

This project pursues 3 complementary objectives all of which are related to communication with AUVs in support of oceanographic and military applications. The first objective is to support the development and testing of the relevant hardware and software needed to demonstrate rendezvous and communication between a submarine and an AUV. This has been identified as a key technology for off-board sensor deployment from a submarine. The FAU Ocean Explorer vehicle provides a cost effective platform for the development and testing process. The second objective is to support oceanographic and mine reconnaissance experiments using acoustic communications to monitor and remotely command multiple platforms in coordinated sampling missions. We have already demonstrated these capabilities. What is needed is further refinement and experimentation to determine operational capabilities and potential for VCW MCM tasks. The third objective is to continue development and application of a very low cost acoustic modem using COTS power line spread spectrum transceivers.

3 APPROACH

3.1 Rendezvous and Acoustic Communication Between and AUV and Submarine

This task is a collaborative effort between FAU and NUWC. The technical challenges associated with acoustic communications will be addressed by NUWC. FAU will focus on the vehicle operation and mission control software. The primary operational challenges for the AUV are high speed long endurance and quiet operation. A typical Navy submarine does not like to go slow. A desirable speed is 4 knots. Extensive modifications have been made to the Ocean Explorer tail section to accommodate faster speeds and quiet operation. The 1999 planned missions included an early spring rehearsal mission to practice and debug all systems including operating at 100

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meters depth for several hours. The full up demonstration was staged in May of 1999 in Hawaii. The planned scenario included 2 way data transfer and control of the AUV by the submarine. Of critical importance is safety of the submarine. Fail safes in the software and operations were developed and implemented.

3.2 Acoustic Remote Control

As the AUV mission goals become more ambitious and complex such as mine counter measures, docking, storm front and gradient following, and feature based navigation, it is important for the AUV software to be able to support such missions. The AUV should not only support pre-programmed missions but also emergency handling, acoustic modem commands that override or place new mission tasks for the AUV, on-line feature based navigation etc. The software should also be intelligent enough to ensure the safety of the AUV, to reconfigure itself to various changing conditions, to provide flexibility to incorporate competing or cooperating behaviors, and to support on-line planning. Without an intelligent software system, it is almost impossible to perform complex AUV missions. As the software system becomes intelligent, it is equally important to keep the interface to the mission programmers simple enough to make sure that human errors are less likely. Achieving all these goals will be a challenging task.

3.3 Very Low Cost Acoustic Modem

The modem consists of a Neuron chip based router module, an Echelon PLC-30 spread spectrum power line transceiver (9 - 90 kHz), a coupling circuit to the amplifier, an amplifier, and acoustic transducer. The parts total about $1000. We have designed and are building 6 of these for testing this year.

4 WORK COMPLETED

One of the first tasks necessary to achieve the ACOMS objectives and AOSN missions is acoustic remote control of the AUV. This needed to be supported for communications using the WHOI/ NUWC modem and the FAU modem as backup. Another command queue was added to the navigator to provide for commands from the WHOI modem. The software was revised and tested. Significant modifications were made to the AUV tail section to accommodate the new podule for higher speed AUV operation. A new propeller was designed. All the AUV systems were disassembled and pressure tested to 300 meters.

During conditioning cycles to quantify maximum performance of the NiCad battery backs it was discovered that they did not vent heat properly and would not charge to full capacity. Due to the short time frame we had to settle on water cooling the AUV during charging in a tub of ice water. Subsequently we have developed a portable air conditioning system that is more convent.

A series of trial runs where conducted in Florida to test the speed, depth, and endurance of the AUV as well as acoustic communications.

The final experiment was conducted in Hawaii south of the islands of Oahu and Lanai. Operations were conducted from the RV Moana Wave which served as the base of operations. Twenty missions were run over an eleven-day period from May 15 through May 24, 1999. The first five days were spent preparing the AUVs and running practice missions with ACOMMS between the AUV and the RV. The last five days were used for the scheduled test events ALPHA, DELTA, GOLF, and JULIET. The ACOMMS payload contained the Woods Hole Oceanographic Institution (WHOI) acoustic modem electronics in a cylindrical aluminum pressure vessel, a high frequency (HF) receiver array, HF projector, and eight Ocean Explorer (OEX) battery packs. The HF

receiver and projector were mounted in a low hydrodynamic drag sail attached to the top of the payload section.The payload also contained the MF tracking transponder that was initially mounted inside the shell. During the course of the operations the transponder was moved to a position protruding from the bottom front of the payload in order to improve the acoustic tracking of the AUV from the surface Research Vessel (RV).

Figure 4.1 ACOMS payload and chase boat Hawaii

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After returning from ACOMS new firmware was installed in the FAU acoustic modems that significantly enhanced performance. The interface software to the AUV was also rewritten for performance reasons. Extensive testing of this new software will be conducted during the AUV Fest 99 and Winter MCM experiments.

The low cost LonTalk modems have been design and the electronics constructed. Tests are scheduled for later in the year.

5 RESULTS

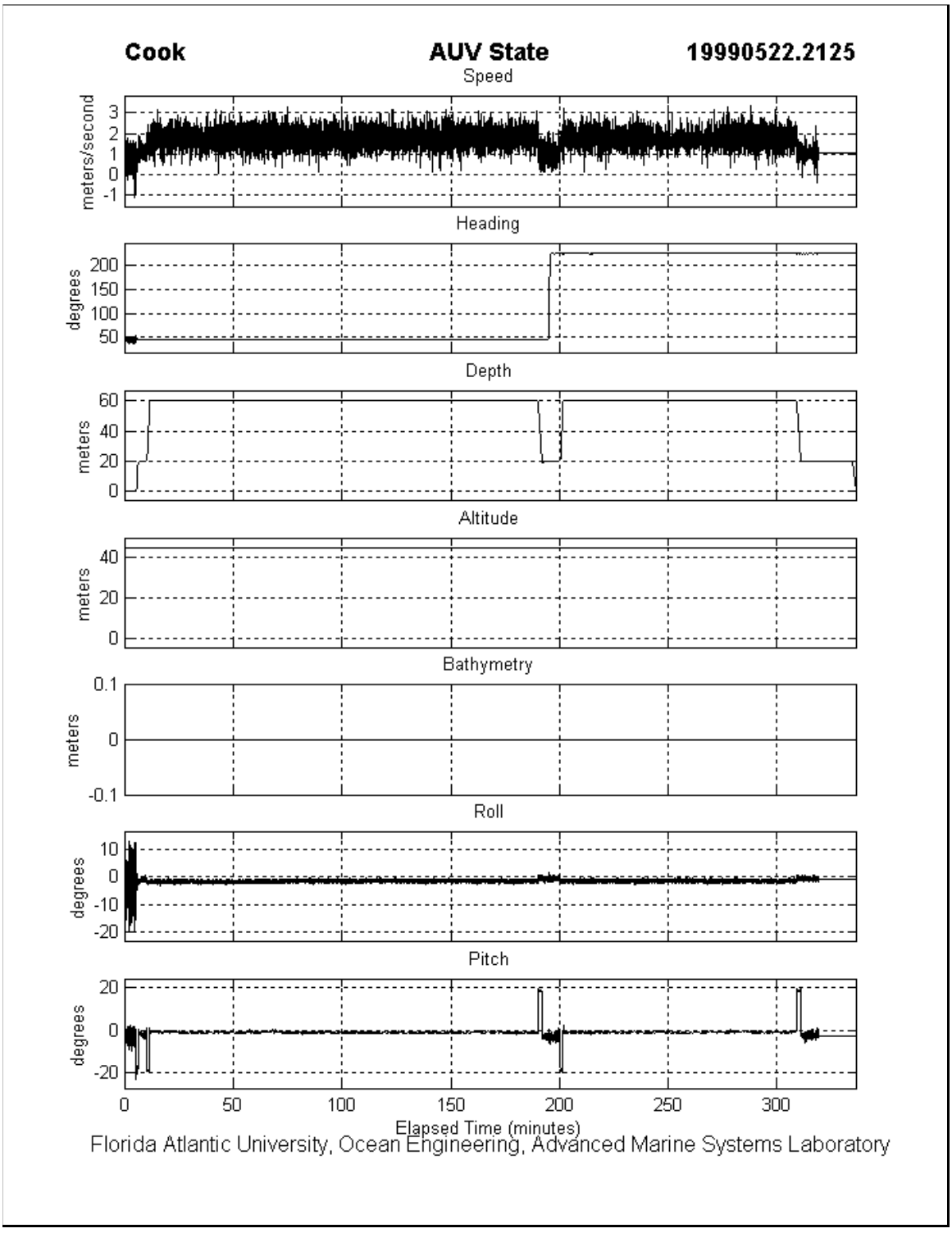
The ACOMS test was successful. The AUV was able to successfully transmit data to the SSN under a variety of conditions. The FAU AUVs operated in very difficult sea conditions and for long durations in less that optimal conditions for tracking.

6 IMPACT/APPLICATIONS

.The success of the ATD lends credence to the use of small AUVs as off-board sensor platforms. Acoustic remote control capabilities prevented the loss of one of the AUVs in Hawaii. It performs a critical recall and mission reconfiguration function essential to integration of AUVs into the fleet

7 TRANSITIONS

The ACOMS ATD success will likely result in integration of the WHOI/NUWC modem into SSNs in the near future. The acoustic remote control capabilities for the FAU AUVs and acoustic networkable modems are part of a NATO SACLANT Commercialization. It is expected that continued use of AOSN capabilities in MCM missions will result in commercialization as well.

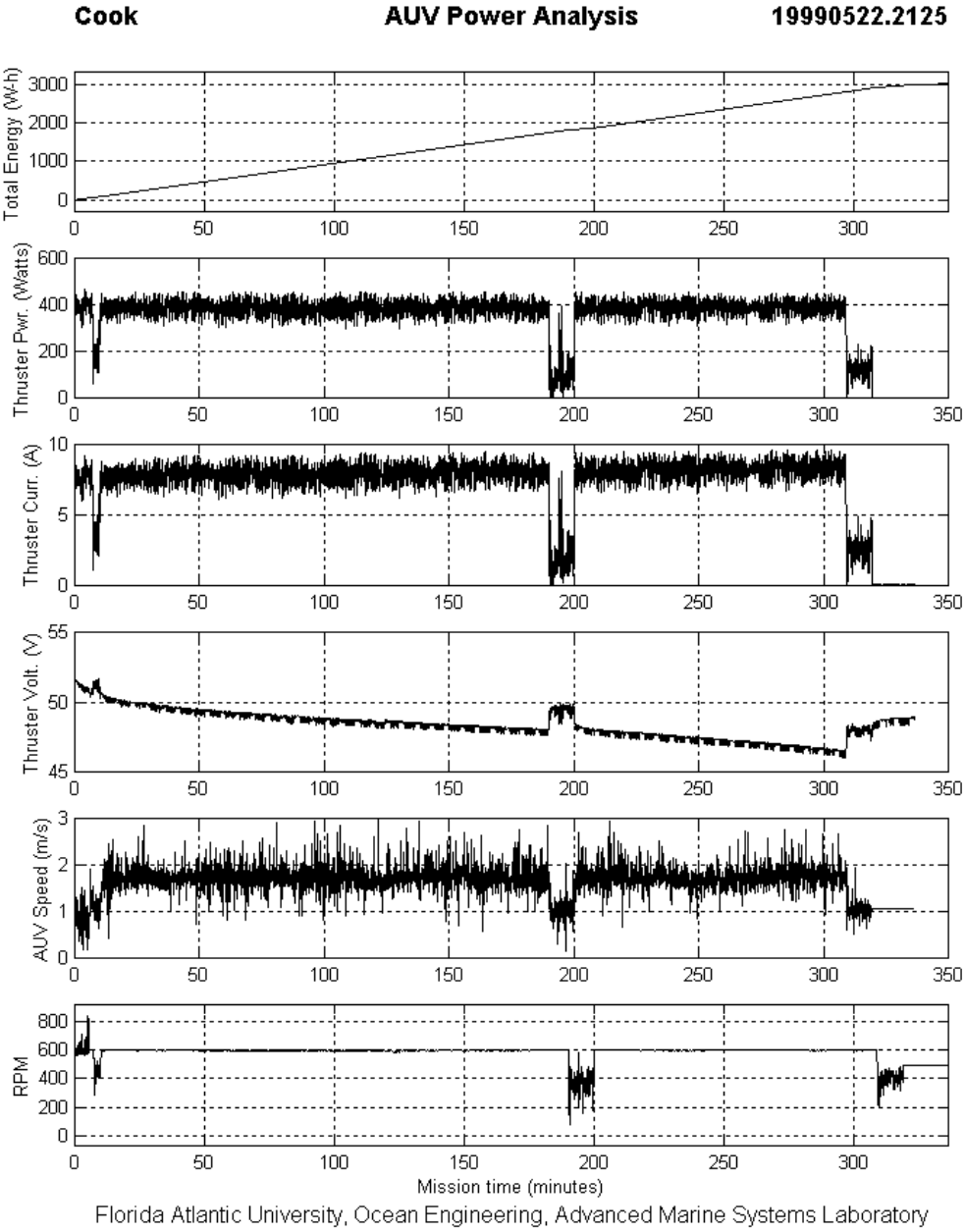


8 RELATED PROJECTS

Coordination of Experiments Using AUVs at the SFTF, ONR.

AUV Hydrodynamics in Shallow Water during Adverse Weather Conditions, ONR.

Acoustic Communications with AUVs and AOSN Development



AUV Navigation and Platform Development

Remote Sampling and Survey of Shallow Water Using AUVs w/application to Mine Reconnaissance and operations support for experiments using the FAU AUVs.

Sampling and Survey with AUVs in Adverse Weather Conditions

ONR MURI on Nonlinear Control

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